EXHIBIT 3

UNITED STATES DISTRICT COURT
EASTERN DISTRICT OF MICHIGAN
SOUTHERN DIVISION

MICHIGAN STATE A. PHILIP RANDOLPH INSTITUTE, ET AL.
Plaintiffs,

v.

RUTH JOHNSON, in her official capacity as Secretary of State of the State of Michigan
Defendant.

Case No. 2:16-cv-11844
Hon. Gershwin Drain

I. INTRODUCTION

1. I am Theodore T. Allen, associate professor of Industrial & Systems Engineering in the Integrated Systems Engineering Department at The Ohio State University (OSU) have been retained by Plaintiffs' Counsel as an expert witness in the above-captioned case. Plaintiffs' Counsel requested that I offer my opinions as to the effects of the elimination of straight ticket voting because of 2015 PA 268. As explained below, my opinion is that PA 268 will almost surely have (1) a negative impact on all Michigan voters and (2) a disproportionately negative effect on African Americans including deterring tens of thousands from voting. It will do this by causing a extra increase in the service times of their voting booths likely causing disproportionate increases in their average waiting times. This follows because of the relatively high historical reliance of African Americans in Michigan on straight ticket voting, e.g., approximately 75% of Detroit voters have used straight ticket voting in 2012 and 2014 compared with approximately 50% of all Michigan voters. The fact that African Americans already experience relatively long measured average waiting times amplifies this effect strongly.

II. QUALIFICATIONS

2. I have been an associate professor of Industrial Engineering in the Industrial Systems & Engineering Department at The Ohio State University (OSU) since 2004. I received my Bachelor of Arts degree from Princeton University (Physics), my Master's degree from the University of California at Los Angeles (UCLA, Physics), and my Ph.D. from The University of Michigan (Ann Arbor, Industrial and Operations Engineering). I have been working in industrial and operations engineering—which includes the study of waiting times for service processes—for 20 years, dating back to a full-time internship at The Ford Motor Company. I have included as Appendix A to this report a copy of my Curriculum Vitae. The following is a brief summary of my education and experience, particularly as it relates to election systems.

3. I have been working at OSU, first as a lecturer, then as an assistant professor, and then as an associate professor, since 1996. The classes that I teach at OSU have included: Applied Waiting Line Analysis (which directly relates to predicting how lines develop as a function of customer arrival and machine service processes); Statistical Modeling, Queuing, and Lean Production (which addresses the mathematical framework of simulation and queuing); Design of Engineering Experiments (addressing statistical planning of engineering experiments); and Empirical Model Building in Industrial Engineering (addressing utility theory and simulation optimization for system design and optimal data collection to support these activities). I have won multiple teaching awards, including the 2000, 2001, 2010, and 2013 Alpha Pi Mu Outstanding Faculty Awards (the top teaching award granted by Industrial & Systems Engineering undergraduate seniors) and the Charles E. MacQuigg Student Award for Outstanding Teaching in 2000.

4. My research areas of interest include the intersection of statistics, operations research, and engineering. My past and current research projects have received over $1.9 million

in awarded grants, from private corporations and public institutions, such as the National Science Foundation, Ford Motor Co., Honda of America Inc., and the Naval Joining Center.

5. I am the author of over 50 publications, including two textbooks, one of which addresses simulation and waiting line theory applications to election systems. I have produced numerous publications related to studying and mitigating election lines including two recent articles in the *Institute of Industrial Engineers Transactions* (2013) and *Productions and Operations Management* (2014), both of which are respected peer-reviewed journals. Some of my relevant publications related to waiting times and elections include:

- Allen, T. T. (2011), *Introduction to Discrete Event Simulation Theory and Agent-Based Modeling: Voting Systems, Health Care, Military, and Manufacturing*, London: Springer-Verlag. (Textbook teaches discrete event simulation, using election system examples to illustrate all the methods.)

- Yang, M., M. J. Fry, W. D. Kelton, and T. T. Allen (2014), "Improving Voting Systems through Service-Operations Management," *Production and Operations Management*. (Explains multiple approaches for election officials to reduce lines with minimal additional expenses, including using our modeling and optimization approaches for deciding how many machines are needed and allocating them to locations accounting for variable ballot lengths.)
- Yang, M., T. T. Allen, M. J. Fry, and W. D. Kelton (2013), "The Call for Equity: Simulation-Optimization Models to Minimize the Range of Waiting Times," *IIE Transactions* 45(7): 781-795. (Focuses on the simulation optimization methods for allocating voting machines to locations to minimize the expected range in waiting times from longest to shortest.)
- Li, J., T. T. Allen, and K. Akah (2013), "Could Simulation Optimization Have Prevented 2012 Central Florida Election Lines?" in *Proceedings of the 2013 Winter Simulation Conference*, R. Pasupathy, S.-H. Kim, A. Tolk, R. Hill, and M. E. Kuhl, eds. (Attempts to recreate the 2012 central Florida general election via simulation and examine what might have happened if voting booths had been apportioned taking ballot length variation into account.)
- Afful-Dadzie, A., T. T. Allen, A. Raqab, and J. Li (2013), "Sufficiency Model-Action Clarification for Simulation Optimization Applied to an Election System," in *Proceedings of the 2013 Winter Simulation Conference*, R. Pasupathy, S.-H. Kim, A. Tolk, R. Hill, and M. E. Kuhl, eds. (Explores an innovative modeling and visualization approach to optimize taking data limitations into account with an election system hypothetical example.)

- Allen, T.T. and M. Bernshteyn (2006), "Mitigating Voter Wait Times," *Chance: A Magazine of the American Statistical Association* 19(4): 25-34. (Shows how regression methods can produce estimates of line lengths and how queuing theory can provide insights into and validated predictions of poll closing times.)

6. I serve on the editorial boards of several peer-reviewed journals including: the *International Journal of Industrial and Systems Engineering*, the *International Journal of Software and Systems Engineering*, and the *Journal of Experimental Design and Process Optimisation*. I am an associate editor of *Computers and Industrial Engineering* and *Quality Approaches in Education*. I am a fellow of the American Society for Quality (ASQ), and an elected leader of a section of the Institute for Operations Research and the Management Sciences (INFORMS) which is a major professional organization related operations research and analytics.

7. I also work frequently as a consultant in both the private and public sectors. With respect to elections, I have consulted to help election officials make resource decisions for projects in Franklin County, Ohio (contains Columbus; multiple engagements over years including planning resource allocations for two general elections), Cuyahoga County, Ohio (contains Cleveland; yearlong project including planning resource allocations for one general election), and Onondaga County, New York (contains Syracuse; working for the Board of Elections to evaluate elections readiness). In Franklin County in 2006, I proposed and was the technical leader for the implementation of perhaps the first principled approach for deciding how many voting machines are needed and how they should be allocated to maximize efficiency and minimize waiting times to vote here. Since then, I have also served as a member of the Ohio State University Senate Apportionment Ad Hoc Advisory Committee (2010).

8. Outside of elections, I have served as a consultant on projects at companies that include: LaBarge, Lucent, Nationwide Services, Timken, and Net Jets. My accomplishments have included: leading a team to significantly reduce average discharge times at a community hospital

and developing methods to accurately forecast maintenance costs associated with an aging fleet of aircraft.

III. TESTIMONY AT TRIAL, DEPOSITIONS, AND AFFIDAVITS

9. I have served as a certified expert witness relating to elections and waiting lines in federal court for Fleming et al. vs. Gutierrez et al. in New Mexico (1:13-cv-00222 WJ-RHS), League of Women Voters of North Carolina et al. vs. The State of North Carolina (Civil Action No. 1:13-CV-660), and OCC vs. Husted (Case No. 2:15cv1802) in Ohio.

IV. COMPENSATION

10. My fee for this case is $200 per hour (nonprofit rate), plus reimbursement for expenses in connection with the case. My fee for deposition testimony and court testimony at locations other than Ohio is $2,100 per day, plus reimbursement for travel and expenses.

V. INFORMATION AND DATA CONSIDERED IN FORMING OPINIONS/METHODOLOGY

11. In preparation for this report I reviewed documents including: voting data from 31 precincts selected to be representative of Michigan voting precincts during the 2016 presidential election including the times spent by voters: waiting, checking in, and casting ballots. From the secretary of state's online data source, I have the numbers of ballots cast and registered voters for the 31 precincts in the 2016 presidential election. I studied four 2016 presidential ballots from Peninsula Township Precinct 2, Meridian Charter Township Precinct 1, Warren City Precinct 26, and City of Saginaw Precinct 16. The key data derived is shown in Exhibit A. The sample average service times in Detroit, Flint, and Saginaw precincts are shown in bold because these have the highest percentages of black voters. According to the 2014 census voting report, these are the only precincts among the 31 in which African Americans outnumber other voter types. Even though fewer than fifty percent of voters in Saginaw are African American, I refer to these as the

"predominantly African American" precincts because African Americans outnumber the other demographic groups.

12. In addition, for this report I reviewed documents including: sample ballots from elections in Ingham, Wayne, and Washtenaw counties, data from a 2014 Polling Location Line Study, data from the 2014 survey of 50 states conducted by Charles Stewart and others, data from the Michigan Secretary of State's website about turnout in 2012 and 2014, data about the number of straight ticket voters in Detroit, Flint, and Lansing in 2012 and 2014, census data about educational attainment, media reports which include the quoting of an official recommendation to plan on 10 to 15 minutes in the booth for the 2008 general election, and the number of registered 2016 voters in Detroit from http://www.waynecounty.com/clerk/1609.htm.

VI. BACKGROUND ON DISCRETE EVENT SIMULATION AND ELECTIONS

13. As we note in Yang, Allen, Fry, and Kelton (2013) and Yang, Fry, Kelton, and Allen (2014), discrete event simulation (or "simulation" here) offers an appropriate way to predict and analyze lines in election systems. Simulation offers flexibility that the queuing theory does not. This added flexibility includes the ability to address systems near 100% utilization without loss in accuracy. Several Michigan precincts in 2016 were confirmed by our data to be operating near or exceeding 100% utilization (average arrival rate exceeds average service rate).

14. As applied to elections, a simulation model can predict average line length; average waiting times to vote; the expected waiting time of the voter who waits the longest; and the number of voters that a system can handle during a time interval. Election systems are relatively simple when compared to other kinds of waiting systems that I have modeled. For example, consider the final assembly of cars at automotive plants, which I have modeled extensively, and which involves hundreds of operations, complicated priority and scheduling inputs, and numerous waiting areas

for parts. Election systems, by contrast, are less complicated as illustrated in Exhibit B. People arrive at a polling place at some rate and are served (*i.e.*, check in and vote) at some rate. A line develops if more people arrive than can be serviced in a given period of time.

Exhibit A. Summary of the data from the 31 precincts including the sample average voting service, waiting, registration or check-in service time.

City or Township	Precinct	# Cast 2016	# Registered	Likely Location # of Booths	Est. Avg. Waiting Time	Percent Straight Ticket	Est. Avg. Voting Service	Est. Avg. Voting Service…No Straight Tick.
Allen Park	15	833	1,205	9	NA	43.9%	5.17	5.74
Augusta	1	1,330	1,826	10	3.33	43.2%	6.52	7.22
Blackman	4	1,541	2,928	14	5.86	54.4%	6.35	7.21
Clinton	22	1,388	2,333	12	6.52	60.8%	5.81	6.70
Curtis	1	647	1,019	13	0.54	45.9%	8.92	9.95
Delta	15	903	1,254	21	4.06	48.6%	10.04	11.26
Detroit	1-271	640	1,505	15	**16.38**	85.0%	**15.27**	**18.51**
Detroit	4-45	464	1497	9	**1.86**	84.1%	**8.65**	**10.47**
Detroit	398	492	1,233	12	**1.99**	82.9%	**12.27**	**14.81**
Farmington Hills	19	1,631	2,156	20	4.94	54.0%	7.89	8.95
Ferndale	2	1,301	1,772	20	5.58	45.9%	7.62	8.49
Flint	2	843	1,714	28	**16.63**	86.2%	**4.44**	**5.40**
Fruitland (Muskegon)	2	1,471	2,219	12	10.22	37.7%	6.06	6.64
Gilmore	1	462	659	8	1.30	47.0%	4.15	4.64
Grand Blanc	4	1,306	1,974	6	2.46	47.3%	5.37	6.01
Grand Rapids	31	1,372	2,297	13	3.57	54.2%	4.22	4.79
Imlay	1	575	998	14	1.08	53.6%	5.19	5.89
La Salle	2	1,492	2,130	15	5.08	34.8%	5.88	6.40
Marion	1	1,640	2,175	20	5.79	46.8%	4.67	5.22
Marquette	2	1,480	2,094	20	3.26	41.4%	5.67	6.25
Meridian	1	1,326	1,619	14	8.19	34.8%	6.16	6.70
Oliver	1	157	262	3	0.33	38.2%	7.33	8.03
Ontwa	2	1,550	2,495	19	1.12	46.5%	4.00	4.46
Orion	1	1,383	1,909	27	3.07	44.8%	7.85	8.73
Peninsula	2	2,176	2,690	12	5.70	38.6%	4.39	4.81
Redford Twp.	9	1,081	1,670	15	6.48	55.6%	7.37	8.39
Rockford City	2	1,950	2,411	14	8.28	41.7%	4.65	5.14
Saginaw	16	1,667	2,772	25	**52.72**	39.3%	**5.56**	**6.10**
Shiawasee (Bancroft)	1	1,558	2,200	13	6.73	42.5%	5.08	5.62
Troy	5	1,211	1,519	13	6.90	43.9%	5.74	6.37
Warren	26	715	1,208	6	1.33	66.3%	5.04	5.87

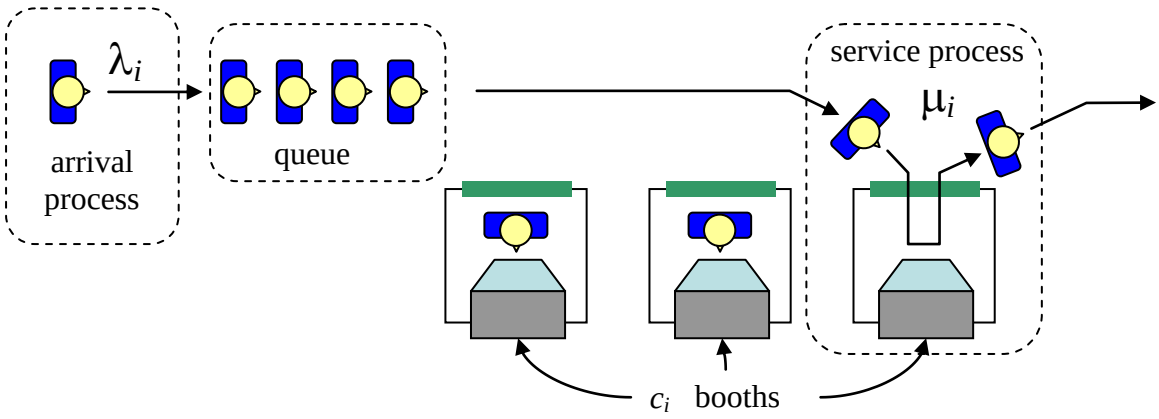
15. Generally speaking, line length and waiting times depend on at least three variables: (1) the number of voters arriving at a polling place; (2) the number of "servers" (such as the number

of booths on which a voter can cast a ballot); and (3) the "service time," that is, the length of time it takes a voter to cast a ballot. Service processes could also include check-in. The ballot marking process could be influenced by factors such as the length of the ballot; the type and complexity of the ballot; and the availability of practices that can reduce voting time, such as straight-ticket voting, in which voters make a single mark indicating that they wish to vote for candidates from the same party for all offices, rather than marking candidates individually for each office.

16. Often, lines develop due to a bottleneck occurring at one of the service operations in a system. In my experience, usually only one of the service operations is the bottleneck, and other operations can be left out of modeling without affecting the results. In election systems, the bottleneck is often the part of the operation in which the voter marks his or her ballot in a booth. I note that the process in which voters check in or register could also serve as a bottleneck, but for the sake of simplicity, I illustrate below a basic model featuring a single (bottleneck) operation, which can be viewed as a voter "monopolizing" a booth as shown in Exhibit B.[1]

[1] I note that this simple model may be viewed as underestimating the average waiting times; if other services processes like registration or checking in are included, then the total waiting times could only increase.

Exhibit B. Illustration of a queuing at a precinct with a bottleneck at booths.



17. Doing a detailed simulation requires a significant amount of data. Fortunately, the data available now about the 31 precincts permits the simulation of a representative sample of all Michigan precincts. The data in Exhibit A represent the most impressive empirical study of which I am aware.

18. Studying the data in Exhibit A of this report and the sample ballots, I estimate that eliminating the option of straight ticket voting would increase the service time of a voter who had previously used straight ticket voting 25% or more. We use the following formula to predict the average service time if straight ticket voting were eliminated:

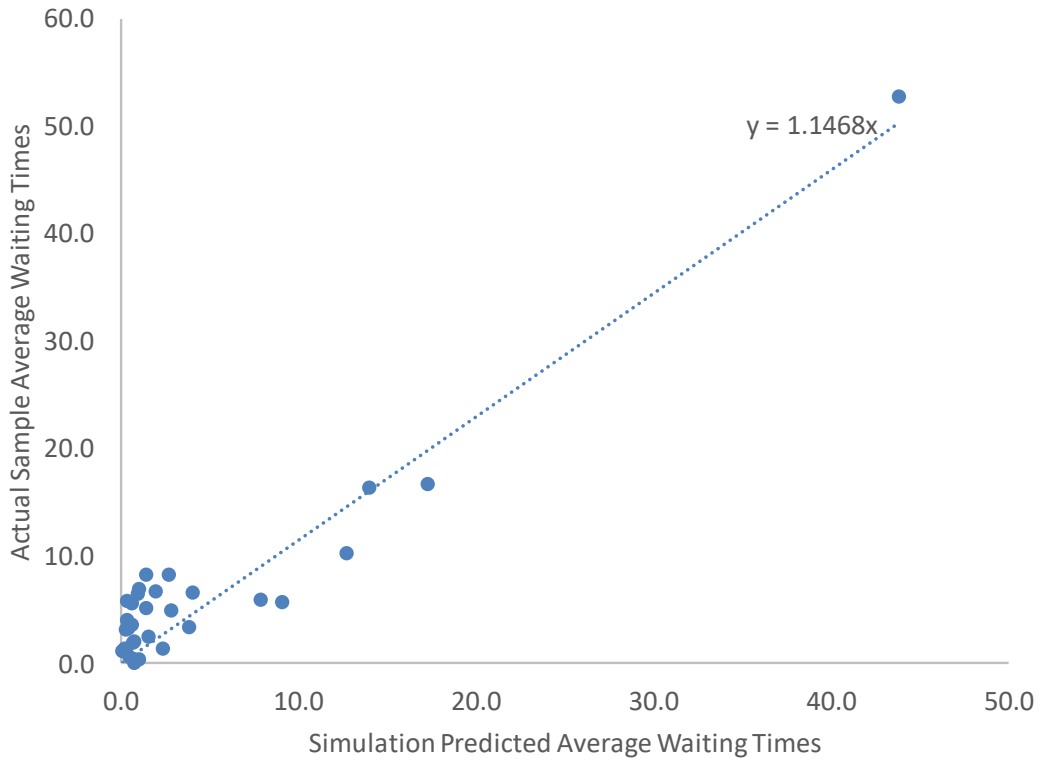
Est. Avg. Voting Service Time = (2016 Est. Avg.) × (1 + %Straight Ticket Voting × ¼) (1)

This is the formula used to predict the times in the right-hand column of Exhibit A. For at least some precincts, this will underestimate the percentage increase and therefore the effects of eliminating straight party voting on waiting times because the partisan section is approximately half of the total ballot. For example, in Saginaw, the 2016 ballot had 15 partisan races, 12 nonpartisan races, and 9 issues. Eliminating the partisan races could easily increase the total time

for some voters by more than one third. Also, the relatively long ballot and failure to provision for that long ballot likely caused the long average waiting times in Exhibit A (52 minutes observed).

19. The simulations were done on the precinct level not the location level. In seven precincts, there was a need to adjust the number of location booths to tailor to the precinct-level model. This was needed for two reasons. First, in some cases the observers indicated that there were additional resources such as desk space which was difficult to quantify. Then, additional resources were added to calibrate the simulation with the measured average waiting times. The adjusted counts were: Augusta 13, Fruitland 13, Grand Blanc 12, and Peninsula 13. Second, in some cases multiple precincts met together and the observer recorded all resources not merely the ones for the precinct. In general, voters are only permitted to use the resources for their own precincts. The adjustments were: Detroit 1-271 13, Flint 5, and Saginaw 11. For all seven adjustments, the resource counts were selected to calibrate the simulation with the measured average waiting times. Exhibit C below demonstrates that the simulation with the adjustments matches the actual average waiting time data measured by the observers.

Exhibit C. The simulated and actual times average waiting times for the 2016 presidential election at the representative precincts is plotted.



VII. THE EFFECT OF WAITING TIMES TO VOTE ON VOTER TURNOUT (THE "THREE PERCENT RULE")

20. A simulation model can provide useful information not only as to how changes in variables (e.g., the allocation of booths, the time it takes to vote, or the number of voters arriving) can affect the length of waiting times, but also about how those changes might ultimately affect turnout. As others have noted (Stewart 2014), waiting in long lines to vote can, among other things, discourage people from voting. In waiting analysis theory terminology, "balking" refers to cases in which people choose not to wait to vote because they perceive waiting times as unacceptable before entering the lines. "Reneging" is the practice of foregoing voting after entering the lines

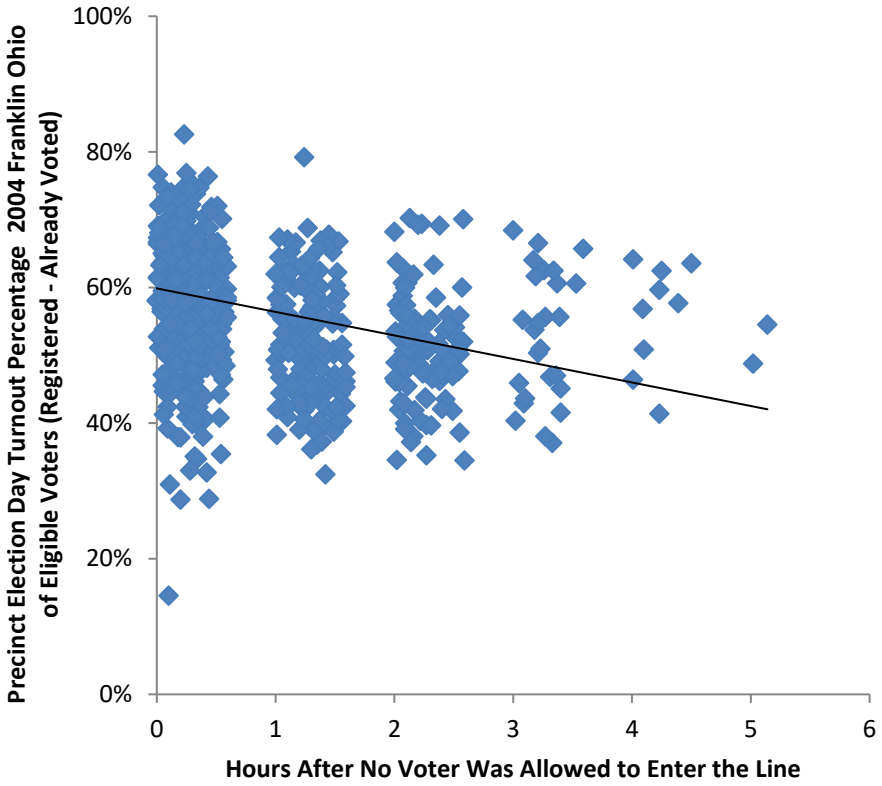
due to the length of the line. Both balking and reneging are important in voting systems because they correspond to reduced voter turnout, or "deterred" votes.

21. Based on regression modeling of election data shown in Exhibit D and Exhibit E, we observe a direct relationship between waiting times to vote and voter turnout, which we can refer to as the "Three Percent Rule." That is, every additional 60 minutes of waiting time results in a decline in turnout of approximately 3% of the remaining eligible voters (those who are registered and who have not voted absentee). As is described below, adding even one minute to the service time can, in some cases, increase the average or maximum waiting times by more than 60 minutes.

22. Specifically, this rule was initially derived from a study of the results of the 2004 Franklin County, Ohio lines at the polls[2]. Exhibit D below illustrates the turnout at 787 precincts in Franklin County, Ohio, plotted against the waiting times to vote at each precinct (using the recorded times approximately when the last voter voted). Each point is, again, a precinct and the overlay is the best fit line which is a linear regression. From Exhibit D, in the 2004 Franklin County elections, we see that, indeed, the turnout was lowest (on average) in the precincts with the longest lines to vote (latest casting times), declining approximately 3% for each additional hour of waiting time to vote.

[2] This data has been described and used in my previous work. *See* Allen & Bernshteyn (2006), *supra* note 5; Yang, Allen, Fry, & Kelton (2013), *supra* note 9.

Exhibit D. Poll Closing Times (in Hours after Line Cut-Off), and Turnout Percentage, Franklin County, 2004.

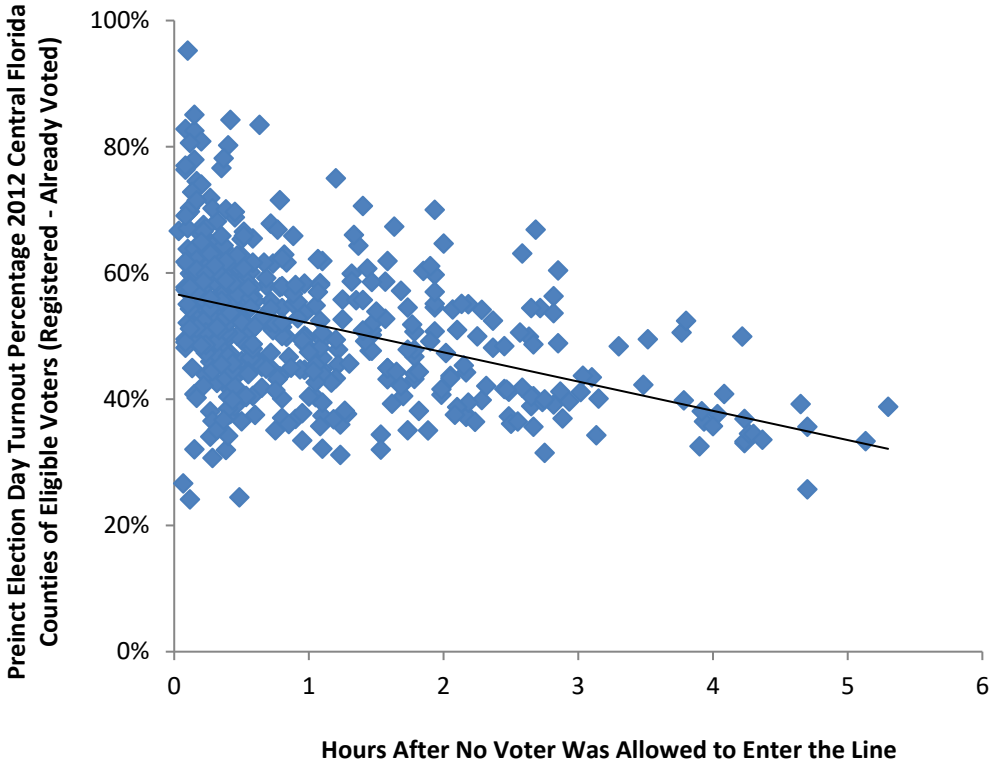


23. There is no reason to assume that the sensitivity of citizens to waiting lines in elections would differ from place to place. In fact, the fit line provides an approximate rule that has subsequently held up well in a more recent election in which there were long lines.[3] Exhibit E illustrates the turnout at 480 central Florida precincts, plotted against the waiting times to vote during the 2012 general election. The fit line in that election is once again approximately consistent with the Three Percent rule. That is, in central Florida during the 2012 election, as in Franklin

[3] *See* Li, Allen, & Akah (2013), *supra* note 8; Allen T. T. (2013, Jan. 8), "Delving into the reasons for long lines can bring solutions," *Orlando Sentinel*, *available at* http://articles.orlandosentinel.com/2013-01-08/news/os-ed-long-lines-voting-florida-010813-20130107_1_long-lines-ballot-length-turnout. (Reviews the data included here, showing that ballot length variation drove closing time variation and later closing times were associated with lower turnouts because of deterred voters.)

County, Ohio during the 2004 election, turnout declined by approximately 3% for each additional hour that aspiring voters had to wait in line to cast a ballot.

Exhibit E. Poll Closing Times (in Hours after Line Cut-Off), and Turnout Percentage, Central Florida 2012 Presidential Election.



24. The Three Percent Rule is based on a time close to the maximum waiting time and not the average waiting time and the percent of eligible voters. Therefore, applying the rule using the average waiting time is quite conservative.

VIII. ANALYSIS OF THE LIKELY EFFECTS OF ELIMINATING STRAIGHT TICKET VOTING

25. I have been asked to use the 2016 data from 31 representative precincts to analyze the likely effects of PA 268 for all Michigan voters and specifically for African American voters. I use the recreation of the 2016 presidential election as an illustrative example. The modeling approach that I use is simple. Based on my analysis, PA 268 would have increased the average service times. Using equation (1), the approximate predictions for the increased average times are derived as shown on the right-hand-side of Exhibit B. Then, using simulation, the predictions for the expected average waiting times and expected maximum waiting times are generated and displayed in Exhibit F.

26. Applying the Three Percent Rule to the differences in average waiting times permits estimation of the effects of average waiting time and the percent of deterred voters in all precincts. These effects are also shown in Exhibit F. For example, consider a hypothetical Detroit precinct with 1,000 eligible voters (registered and have not yet voted). If the model predicts an increase of one hour in average waiting, then 3% or 30 voters would be deterred from voting. If the expected maximum waiting time increased by two hours, and the Three Percent Rule were based less conservatively on the expected maximum times, another estimate would be 60 voters deterred.

27. Next, the increase in the average waiting times in all precincts is weighted by the votes cast. The results are multiplied by 3% to estimate the weighted loss percentages, i.e., the percent of eligible voters deterred: 2.0% for predominantly African American precincts and 0.25% for predominantly non-African American precincts. Repeating this calculation using the expected maximum waiting time increases results in deterring 3.4% of eligible voters in predominantly African American precincts and only 0.34% in the predominantly non-African American precincts. Thus, eligible African American voters are deterred at ten times the rate of non-African American

voters. Using the expected maximum waiting times is more accurate since the Three Percent Rule is approximately based on the actual maximum waiting times.

Exhibit F. Simulation of 2016 Waiting Times and Estimates of Waiting Times Without Straight Ticket Voting.

City or Township	Precinct	Simulation of 2016		Estimate without Straight Ticket			
		Exp. Avg. Waiting Time	Exp. Max. Waiting Time	Exp. Avg. Waiting Time	Exp. Max. Waiting Time	Exp. Avg. Difference	Exp. Max. Difference
Allen Park	15	0.74	15.82	1.10	17.88	0.35	2.07
Augusta	1	3.83	23.10	12.19	34.65	8.36	11.54
Blackman	4	7.84	27.45	25.40	49.82	17.57	22.36
Clinton	22	4.03	23.45	19.77	42.65	15.75	19.21
Curtis	1	0.45	12.49	0.73	14.52	0.29	2.03
Delta	15	0.34	11.59	0.46	12.40	0.12	0.82
Detroit	1-271	13.97	37.22	72.19	129.68	**58.22**	**92.45**
Detroit	4-45	0.66	14.19	1.26	16.21	**0.61**	**2.02**
Detroit	398	0.74	13.81	1.66	17.07	**0.92**	**3.26**
Farmington Hills	19	2.80	20.85	9.88	30.10	7.08	9.25
Ferndale	2	0.63	14.89	0.85	16.41	0.22	1.51
Flint	2	17.28	40.76	82.62	143.60	**65.34**	**102.84**
Fruitland (Musc.)	2	12.72	33.95	32.70	58.03	19.98	24.08
Gilmore	1	0.16	7.06	0.20	7.99	0.04	0.94
Grand Blanc	4	1.52	19.71	2.79	22.59	1.27	2.88
Grand Rapids	31	0.56	14.53	0.79	16.28	0.23	1.76
Imlay	1	0.09	5.29	0.11	6.34	0.02	1.05
La Salle	2	1.38	19.11	2.16	21.43	0.78	2.31
Marion	1	0.35	11.83	0.46	13.21	0.11	1.38
Marquette	2	0.40	12.72	0.55	14.34	0.14	1.62
Meridian	1	1.41	19.33	2.45	21.74	1.04	2.41
Oliver	1	0.99	13.73	1.77	16.32	0.79	2.58
Ontwa	2	0.28	10.21	0.33	11.19	0.05	0.99
Orion	1	0.28	10.88	0.36	11.89	0.08	1.01
Peninsula	2	9.07	29.72	27.05	48.77	17.98	19.05
Redford Twp.	9	0.90	16.61	1.91	19.68	1.01	3.07
Rockford City	2	2.67	22.24	7.72	27.59	5.06	5.35
Saginaw	16	43.81	74.07	87.68	153.13	**43.87**	**79.06**
Shiawasee (Ban.)	1	1.94	20.88	4.92	24.41	2.97	3.54
Troy	5	0.98	17.28	1.55	19.26	0.57	1.97
Warren	26	2.35	21.37	9.78	31.17	7.43	9.80

28. Since the 31 precincts were chosen to be representative of the state, the derived estimates approximately extrapolate to the rest of the state. There was a total of approximately 7.4 million registered voters including approximately 0.9 million registered African Americans in 2016. Approximately 27.4% voted absentee so they were ineligible to vote on election day. This leaves 4.7 million eligible non-African American and 650,000 eligible African Americans. Therefore, I estimate that 13,000 (based on the averages) and 22,000 (based on the maximums) African Americans would have been deterred by PA 268. Also, 12,000 (based on the averages) and 16,000 (based on the maximums) non-African Americans would have been deterred. Even the estimates based on the expected maximum waiting times are likely conservative because the Three Percent Rule only includes those deterred who were aware of the local lines. In either accounting, over 50% of the deterred voters would have been African Americans even though they constituted less than 12% of the registered voters. Therefore, even while African Americans are a small minority of the overall population, PA 268 would effectively target them with long lines depressing their vote in relatively large absolute terms.

IX. CONCLUSIONS

29. I render the following opinions within a reasonable degree of professional certainty. I retain the right to amend or supplement my opinions if additional information or materials become available.

30. The elimination of straight ticket voting would cause increased waiting times throughout Michigan since average service times would increase. For the African Americans in major cities including Detroit, Flint, and Saginaw, the negative impact of eliminating straight ticket voting will likely be far more substantial than in other places. This follows because a higher fraction of the voters will be experiencing longer service times on the partisan section. These

longer service times will likely be made worse by their comparatively lower literacy. Also, the 2016 observed waiting times were already significantly longer in the predominantly African American precincts. This amplifies the disparate effect of the service time increase. As a result, the average waiting line increases caused by 2015 PA 268 would fall approximately ten times harder on the predominantly African American precincts than on the other precincts. This disparate effect would likely affect future elections harming African American voters significantly more than others, effectively disenfranchising them by the tens of thousands.

I declare under penalty of perjury under the laws of the United States that the foregoing is true and correct to the best of my knowledge.

DATED this 30th day of June 2017 Theodore T. Allen

Theodore Allen, PhD

Appendix A – Curriculum Vitae

THEODORE T. ALLEN
Department of Industrial, Welding & Systems Engineering
The Ohio State University, 210 Baker Systems, 1971 Neil Ave., Columbus, OH 43210
(614) 292-1793 www-iwse.eng.ohio-state.edu/~facultyp/allen.htm

Education

PRINCETON UNIVERSITY, B.A. 1991, Physics (Honors), certificate in Engineering Physics

UCLA, M.S. 1992, Physics (Solid State)

THE UNIVERSITY OF MICHIGAN, M.S. 1994, Ph.D.1997, Industrial & Operations Engineering

Appointments

THE OHIO STATE UNIVERSITY (OSU), Industrial, Welding & Systems, Columbus, OH
8/04-present Associate Professor
8/97-8/04 Assistant Professor
8/96-8/97 Instructor

FORD MOTOR COMPANY, Climate Control Operations, Advanced Engineering
5/94 –8/96 Advanced engineer to heating, ventilating, and cooling including fans and cowls

Publications

(i) Selected Five Relevant to Case

1. Yang, M., Fry, M. J., Kelton, W. D., & Allen, T. T. (2014). Improving Voting Systems through Service-Operations Management. *Production and Operations Management*, 23(7), 1083-1097.
2. Yang, M., T. T. Allen, M. Fry, and D. Kelton (2013). The Call for Equity: Simulation-Optimization Models to Minimize the Range of Waiting Times. *IIE Transactions*, 45, 1–15.
3. Li, J., T. T. Allen, and K. Akab (2013). Could Simulation Optimization Have Prevented 2012 Central Florida Election Lines. *Proceedings of the 2013 Winter Simulation Conference*, R. Pasupathy, S.-H. Kim, A. Tolk, R. Hill, and M. E. Kuhl, eds.
4. Afful-Dadzie, A. and T. T. Allen (2013). Sufficiency Model-Action Clarification for Simulation Optimization Applied to an Election System. *Proceedings of the 2013 Winter Simulation Conference*, R. Pasupathy, S.-H. Kim, A. Tolk, R. Hill, and M. E. Kuhl, eds.
5. Allen, T. T. (2011), *Introduction to Discrete Event Simulation Theory with Applications: Voting Systems, Health Care, Military, and Manufacturing*, Springer Verlag: London.

(ii) Selected Additional Five Significant Publications

1. Afful-Dadzie, A., & Allen, T. T. (2014). Data-driven cyber-vulnerability maintenance policies. *Journal of Quality Technology*, 46(3), 234.
2. Allen, T. T. and R. Rajagopalan (2011). Response-Probability Model Analysis Plots. *Journal of Quality Technology*, 43, 3, 224-235.
3. Allen, T. T. (2010). *Introduction to Engineering Statistics and Lean Sigma: Statistical Quality Control and Design of Experiments and Systems*. 2nd ed., Springer Verlag: London.

4. Huang, D., T. T. Allen, W. Notz, and N. Zheng (2006). Global Optimization of Stochastic Black-Box Systems via Sequential Kriging Meta-Models. *Journal of Global Optimization*, 34 (3), 427-440.
5. Allen, T. T. and M. Bernshteyn (2003). Supersaturated Designs that Maximize the Probability of Finding the Active Factors. *Technometrics*, 45 (1), 1-8.

Synergistic Activities

1. **Innovations in Teaching and Training:** (1) Developed the syllabus, course materials, and taught over 2,500 engineering students applied statistics in courses including simulation and design of experiments, (2) developed second edition textbook with all sales (in print and web) exceeding 10,000.
2. **Professional Service:** President-elect Informs Social Media Analytics Section. Formerly Informs Prize Committee. Informs Public Sector OR elected treasurer. INFORMS Social Media Analytics Newsletter Editor. Lead team to implement theory-based machine allocation in Franklin County, Ohio in 2008 and 2010. Lead technical team to implement theory-based allocation in Cuyahoga County, Ohio in 2008. The allocations helped to reduce waiting times and increase equity in the presidential election.
3. **Founder and sole proprietor of Sagata Ltd.:** Software and consulting company.
4. **Additional Service:** Expert witness in Ohio, New Mexico, and North Carolina.
5. **Editorial Positions:** Associate editor *Computers and Industrial Engineering*, associate editor *Quality Approaches in Higher*, Editorial board of *IJISE, IJSSE,* and *IJEDPO*. 2009 reviewer for: *Bioinformatics*, *IIE Transactions*, *Technometrics*, *JQT*, *IJQSR*, *QE*, and *CDSA*.

Collaborations and Other Affiliations

1. **Ph.D. Advisors:** Gary Herrin (University of Michigan, chair), Vijay Nair (University of Michigan), C. J. F. Wu (Georgia Tech University)
2. **Collaborators:** David Farson (The Ohio State University), Nicholas Hall (The Ohio State University), Mario Lauria (Telethon Institute of Genetics and Medicine), William Notz (The Ohio State University), Fritz Scheuren (NORC), David Woods (The Ohio State University)
3. **Ph.D. Students (chair or primary chair):** Afful-Dadzie, Anthony (2012), Lee, Soo Ho (2012), Hui Xiong (2011), Ravishankar Rajagopalan (2009), Taslim, Cenny (2008), Zheng, Ning (2008), Tseng, Shih-Hsien (2008), Schenk, Jason (2008), Ferhatosmanoglu, Nilgun (2007), Brady, James (2005), Huang, Deng (2005), Chantarat, Navara (2003), Ittiwattana, Waraphorn (2002), Bernshteyn, Mikhail (2001), Ribardo, Charles (2000), Yu, Liyang (2000)

Honors and Awards

1. 2016 Informs Volunteer Service Award
2. Finalist 2015 Informs Social Media Competition Best Student Paper Competition co-author
3. Winner *2013 Quality Approaches In Higher Education* Best Paper Prize
4. Fellow of the *American Society of Quality* (ASQ)
5. Charles E. MacQuigg Student Award for Outstanding Teaching (2001, OSU)
6. Alpha Pi Mu Outstanding Faculty Awards (2013, 2011, 2010, 2002, and 2001 only a single faculty member gets this each year as voted by the graduating seniors)
7. 1 of 100 "outstanding engineers from engineering and industry" selected to attend the 2010 Frontiers of Engineering Education Symposium by the National Academy of Engineering

8. Interviewed on NYT, CNN, CNNi, and in *Time* for voting machine allocation expertise

Appendix B – Documents Considered

1. Simulation Software with Raw and Processed Data Loaded.
2. 2016 Ballot Peninsula Township Precinct 2.
3. 2016 Ballot Meridian Charter Township Precinct 1.
4. 2016 Ballot Warren City Precinct 26.
5. 2016 Ballot City of Saginaw Precinct 16.
6. 31 Reports from Election Precincts During the 2016 Presidential Election.
7. General Assembly of Michigan Senate Bill 15, 2015.
8. 2014 Sample Ballot from Wayne County.
9. 2012 Sample Ballots from Ingham, Wayne, and Washtenaw.
10. 2008 Sample Ballot from Ingham.
11. Polling Location Line Study - Southfield Township, Oakland County.
12. 2014 Survey Data from Charles Stewart and others.
13. Data from the Michigan Secretary of State's Website Including http://www.waynecounty.com/clerk/1609.htm.
14. "DataAboutStraightTicketAndNewspaperArticles.pdf" which contains straight ticket voting data from 2012 and 2014 in Detroit, Lansing, and Flint as well as census data about educational attainment in Michigan and newspaper reports which quote instructions from the state to plan on 10 to 15 minutes in the booth.
15. Census 2014 Community Survey https://www.census.gov/content/dam/Census/library/visualizations/2016/comm/cb16-tps37_graphic_voting_michigan.pdf.